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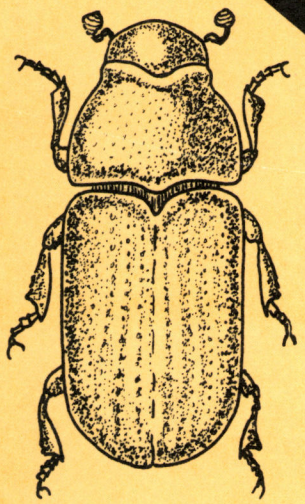

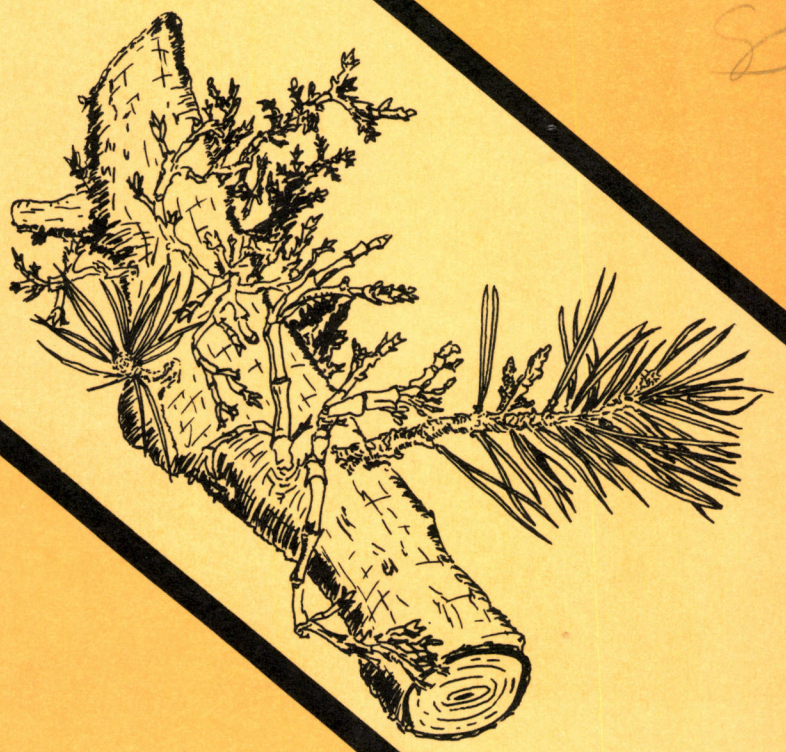

Southwestern Region

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BIOLOGICAL EVALUATION
Southwestern Dwarf Mistletoe

Extension Area B
Grand Canyon Dwarf
Mistletoe Control
Project, South Rim,
Grand Canyon
National Park,
Arizona

1972

Branch of Forest Insect and Disease Management
Division of Timber Management
Southwestern Region, USDA, Forest Service
517 Gold Avenue, SW
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INTRODUCTION

Southwestern dwarf mistletoe (Arceuthobium vaginatum subsp. cryptopodum (Engelm.) Hawks. and Weins) is the most destructive parasite of ponderosa pine (Pinus ponderosa var. scopulorum Engelm.) in the Southwest. It attacks trees of all ages, causing decreased vigor, decline, and premature death.

In 1949, the National Park Service began a large-scale dwarf mistletoe control project in the ponderosa pine forest on the South Rim of Grand Canyon National Park (Fig. 1). A research paper, soon to be published, describes the project as carried out from 1949 to 1972 (Lightle and Hawksworth, 1973). This project has covered three areas: The Original Control Area (1,100 acres), Extension Area A (840 acres), and Extension Area B (408 acres). The Original Control Area and Extension Area A have received an initial treatment, and at least two follow-up treatments. Extension Area B was treated for the first time in 1966-1969, and has received no follow-up treatments.

This is a report on a biological evaluation of Extension Area B. The purpose of the evaluation was to determine the current and potential significance of dwarf mistletoe in Extension Area B, and to recommend the most appropriate suppression measures. The evaluation was based on the results of a survey conducted in July 1972.

SURVEY PROCEDURE

Survey lines were run perpendicular to the telephone line at the south boundary of Extension Area B (Fig. 1), and spaced approximately 5 chains apart. Plot centers were located at 3-chain intervals along the lines. At each plot center, two types of plots were established. One was a variable-radius plot for large trees and the other was a 1/20-acre, fixed-radius plot for small trees. The 10 basal area factor scale of a Relaskop was used in establishing the variable-radius plots.

The diameter of each tree on the plots was measured at breast height and recorded by 2-inch diameter classes. Trees from 1 foot in height to 2.9 inches in diameter were included in the 2-inch diameter class. Other diameter classes were 4-inch - 3.0 to 4.9; 6-inch - 5.0 to 6.9; 8-inch - 7.0 to 8.9; etc. Trees in the 2-, 4-, and 6-inch diameter classes were recorded on the fixed-radius plots. Trees in the 8-inch and larger diameter classes were recorded on the variable-radius plots.

The intensity of dwarf mistletoe in each tree was rated by the 6-class mistletoe rating system (Fig. 2). Healthy trees (trees not visibly infected) were recorded as "0". Infected trees were recorded in 6 classes, ranging from 1 for the most lightly infected to 6 for the most severely infected.

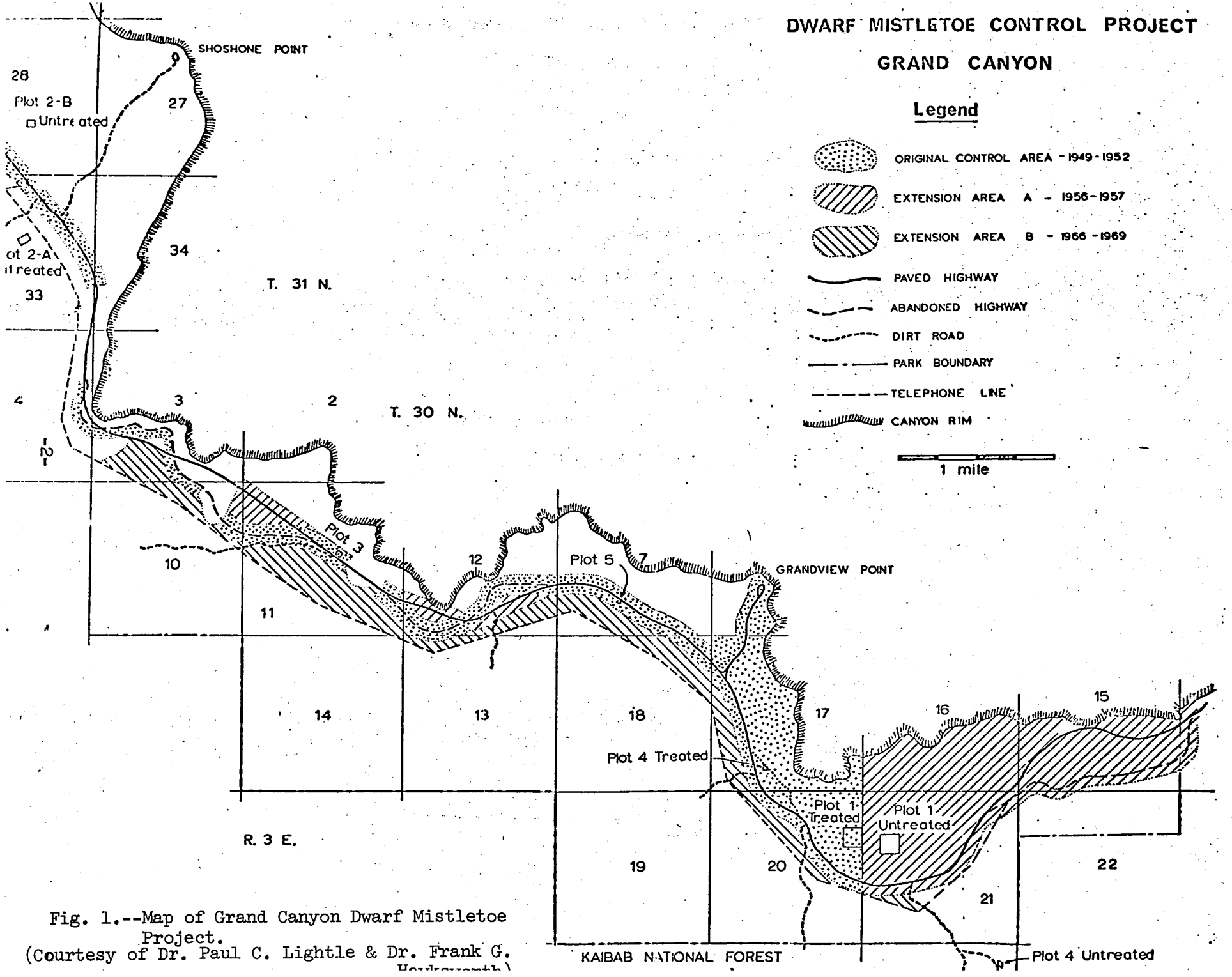


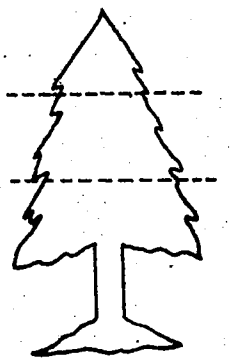
Fig. 1.--Map of Grand Canyon Dwarf Mistletoe Project.
(Courtesy of Dr. Paul C. Lightle & Dr. Frank G. Hawksworth)

6-CLASS MISTLETOE RATING SYSTEM

INSTRUCTIONS

STEP 1: DIVIDE LIVE CROWN INTO THIRDS.

STEP 2: NOW, RATE EACH THIRD SEPARATELY. EACH THIRD SHOULD BE GIVEN A RATING OF EITHER 0, 1, OR 2 AS DESCRIBED BELOW.
(0) No visible infections
(1) Light infection ($\frac{1}{2}$ or less of total number of branches in the third infected)
(2) Heavy infection (more than $\frac{1}{2}$ of total number of branches in the third infected)



STEP 3: FINALLY, ADD RATINGS OF THIRDS TO OBTAIN RATING FOR TOTAL TREE.

Fig. 2.--Instructions for use of the 6-class mistletoe rating system (Hawksworth and Lusher 1956).

Bole infections were considered only in trees in the 2-, 4-, and 6-inch diameter classes. A record was kept of trees with bole infections, or branch infections that had invaded the bole. The following table, based on information from Hawksworth and Andrews (1965), was used to determine if invasion of the bole had occurred.

Branch diameter at bole (inches)	Minimum distance from bole to closest shoots (inches)
Under 1	6
1 to 2	8
2 to 3	10
3 to 4	12

If shoots were closer than the minimum distance indicated, the branch infection was considered to have entered the bole. Trees in the 2-, 4-, and 6-inch diameter classes with bole infections were also rated by the 6-class rating system. Each crown third with one or more bole infections, but no branch infections, was assigned a rating of one. If branch infections were present in the third, bole infections were disregarded.

ANALYSIS OF SURVEY DATA

Data from both the variable-radius and fixed-radius plots were compiled and analyzed with a computer program, NSEC, developed for the Branch of Forest Insect and Disease Management, Region 4, U.S. Forest Service, Ogden, Utah. The program provided tables showing an estimated average number of trees per acre for each diameter class and dwarf mistletoe condition. The program also carried out a statistical analysis of the survey data. Diameter classes used in the analysis were the same as those recorded during the survey. Dwarf mistletoe-infected trees were entered as either "prune" or "cut." Trees recorded in infection classes 1 and 2 on the variable-radius plots were entered as "prune" trees; trees in classes 3, 4, 5, and 6 were entered as "cut" trees. For the fixed-radius plots, trees in infection classes 1 and 2 without bole infections or branch infections that had invaded the bole were entered as "prune" trees; all others were entered as "cut" trees.

RESULTS AND DISCUSSION

A total of 195 variable-radius and 195 fixed-radius plots were established during the survey. The results of this sample as compiled and analyzed with the NSEC program are presented in Appendix Tables 1, 2, 3, and 4. For the 8-inch and larger diameter classes (sampled with variable-radius plots), the estimated average number of trees per acre was 21.28: 17.35, healthy; 2.42, prune; 1.51, cut (Appendix Table 1). For the 6-inch and smaller diameter classes (sampled with fixed-radius plots), the estimated average number of trees per acre was 209.23: 199.59, healthy; 4.62, prune; 5.03, cut (Appendix Table 3). About 18 percent of the trees in the 8-inch and larger diameter classes were visibly infected (Appendix Table 1). In contrast, less than 5 percent of trees in the smaller diameter classes were infected (Appendix Table 3). Results of the statistical analysis are presented in Appendix Tables 2 and 4.

Extension Area B was first treated during 1966-1969. Heavily infected trees were felled or poisoned, and lightly infected trees were pruned. No treatments have been carried out since that time.

Many trees now in need of pruning were pruned during the first treatment, but contained latent infections in residual branches. In A. vaginatum subsp. cryptopodum, a 3- to 5-year latent period elapses after infection before aerial shoot production begins. New Infections cannot be detected until after the latent period.

Several trees in the "cut" category were frilled and poisoned during the first treatment, but failed to die. Some "cut" trees in the 6-inch and smaller diameter classes were probably missed during the first treatment. During past control operations, we have observed that workers tend to overlook infections in small trees.

With no further pruning or cutting, intensification (increase in the number of dwarf mistletoe plants in a tree) can be expected to begin again. Trees which could have been pruned will become too severely infected for pruning to be effective. Intensification occurs at an average rate of one infection class (6-class rating system) every 10 to 12 years. Decline in growth rate and vigor begins after a tree reaches class 4 and continues through classes 5 and 6. The average life expectancy of class 6 trees is about 30 years, but varies with tree size and age (Lightle and Hawksworth, 1973).

Spread (increase in the number of dwarf mistletoe-infected trees in a stand) can also be expected. Overstory spread (spread from overstory to understory due to seeds dispersed from the overstory) will occur within a radius of 40-50 feet from the bole of the infected overstory trees. Once dwarf mistletoe is established in reproduction around the overstory trees, subsequent spread can begin. Subsequent spread (apread in a stand beyond the limits of seed dispersal from an overstory) occurs at an average rate of 1 to 2 feet per year.

Hawksworth (1967) determined the distribution of dwarf mistletoe on the South Rim of Grand Canyon. It occurs both north and south of Extension Area B. Dwarf mistletoe to the north of Area B was in the Original Control Area, and has been reduced to a very low level. During the survey, dwarf mistletoe was observed at several points along the south boundary. Some invasion across this boundary is likely. Invasion occurs at an average rate of less than 2 feet per year, but will initially be lessened in this case by a telephone line right-of-way (Fig. 1).

Bole infections are important only in trees in the 6-inch and smaller diameter classes. In larger trees, they usually produce few shoots and seeds, and have little or no effect on tree growth and vigor.

During the survey, a few dwarf mistletoe plants were observed bearing mature fruit. This indicates that a small amount of intensification and spread could have occurred since the first treatment. Infections bearing mature fruit in July 1972 were probably established before 1966-1969, since the minimum time required from infection to production of the first mature fruit averages 7 to 8 years in A. vaginatum subsp. cryptopodum.

CONCLUSIONS AND RECOMMENDATIONS

Extension Area B has been treated once, and only a small amount of dwarf mistletoe is now present. A follow-up treatment should be considered before intensification and spread resume.

A follow-up treatment would not eliminate the dwarf mistletoe population, but would reduce it to a level likely to be unimportant for many years. Reproduction now exposed to an infected overstory would, in our opinion, have a much better chance of reaching maturity. Ideally, the follow-up treatment should be carried out during 1973. If more than 1 year will be required, follow-up should begin in the eastern portion of the area. This is the oldest (1966) treated portion, and is likely to have the greatest number of seed-bearing dwarf mistletoe infections.

Without a follow-up treatment, intensification and spread can resume. The dwarf mistletoe population will increase, but no readily noticeable change in tree health is likely to occur for several years. The first noticeable effect of intensification would probably be a gradual decrease in the vigor of individual trees or small groups of trees. After many years, some mortality could be expected. Reproduction now exposed to infected overstory trees would, in our opinion, have a poor chance of reaching maturity.

A list of suggestions is included in the Appendix for use when a follow-up treatment is carried out. The suggestions were based on this evaluation, prior experience, and several papers, including Lightle, Paul C., and Frank G. Hawksworth (1973); Hawksworth, Frank G. (1961); and Hawksworth, Frank G., James L. Stewart, and Wilmer F. Bailey (1968).

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APPENDIX TABLE 1

SURVEY
112072

POPULATION STAND TABLE
S. RIM GRAND CANYON
HOST SPECIES IS PONDEROSA PINE

THE INSECT NAME IS S W DWARF MISTLETOE

THE METHOD OF SAMPLING WAS VARIABLE. THE FIGURES IN THIS TABLE ARE BASED ON A SAMPLE OF 195 PLOTS, AND REPRESENT AN AREA OF 408.40RES.

BAF WAS 10.

THIS TABLE ONLY INCLUDES HOST TREES

NUMBERS OF TREES PER ACRE

DBH	HEALTHY	PRUNE	CUT	N/A	TOT. INF.	PERCT. INF.	TOTAL	PERCENTILE
7.0- 8.9	2.644	0.294	0.147	0.000	0.441	14.286	3.085	14.496
9.0- 10.9	2.633	0.138	0.232	0.000	0.470	15.152	3.103	14.579
11.0- 12.9	2.416	0.261	0.392	0.000	0.653	21.277	3.069	14.419
13.0- 14.9	1.247	0.192	0.048	0.000	0.240	16.129	1.487	6.987
15.0- 16.9	1.432	0.857	0.110	0.000	0.367	20.408	1.800	8.456
17.0- 18.9	1.625	0.319	0.145	0.000	0.464	22.222	2.089	9.817
19.0- 20.9	1.410	0.094	0.094	0.000	0.188	11.765	1.598	7.510
21.0- 22.9	0.971	0.194	0.117	0.000	0.311	24.242	1.282	6.024
23.0- 24.9	0.767	0.131	0.033	0.000	0.163	17.544	0.930	4.372
25.0- 26.9	0.695	0.195	0.056	0.000	0.250	26.471	0.946	4.444
27.0- 28.9	0.672	0.108	0.024	0.000	0.132	16.418	0.804	3.775
29.0- 30.9	0.356	0.125	0.042	0.000	0.167	31.373	0.533	2.503
31.0- 32.9	0.230	0.037	0.000	0.000	0.037	13.793	0.266	1.251
33.0- 34.9	0.106	0.016	0.008	0.000	0.024	18.750	0.130	0.611
35.0- 36.9	0.090	0.007	0.000	0.000	0.007	8.333	0.097	0.409
37.0- 38.9	0.033	0.000	0.007	0.000	0.007	16.667	0.039	0.184
39.0- 40.9	0.018	0.000	0.006	0.000	0.006	25.000	0.024	0.110
41.0- 42.9	0.005	0.005	0.000	0.000	0.005	50.000	0.011	0.050
TOTAL	17.35	2.42	1.31	0.00	3.93	18.48	21.28	100.00
PERCENT	81.52	11.39	7.09	0.00	18.48			

BASAL AREA PER ACRE FOR HOST TREES

HEALTHY	PRUNE	CUT	N/A	TOT. INF.	TOTAL
28.7179	4.8718	2.2564	0.0000	7.1282	35.8462

APPENDIX TABLE 2

STATISTICAL ANALYSIS FOR HOST TREES

South Rim, Grand Canyon

	Est. Ave. No. of Trees Per Acre[1/]	Standard Error	Coefficient of Variation
Healthy	17.35 ± 1.58	1.61	129.57
Prune	2.42 ± 0.45	.46	262.72
Cut	1.51 ± 0.34	.35	324.07
Tot. Inf.	3.93 ± 0.59	.60	216.58
Total	21.28 ± 1.61	1.64	107.52

1/ 95 percent confidence limits.

APPENDIX TABLE 3

POPULATION STAND TABLE
S RIM GRAND CANYON
HOST SPECIES IS PONDEROSA PINE THE DISEASE NAME IS S W DWARF MISTLETOE

THE METHOD OF SAMPLING WAS FIXED THE FIGURES IN THIS TABLE ARE BASED ON A SAMPLE OF 195 PLOTS, AND REPRESENT AN AREA OF 408. ACRES.

PLOT SIZE = 0.050 ACRES.

THIS TABLE ONLY INCLUDES HOST TREES

NUMBERS OF TREES PER ACRE

DBH	HEALTHY	PRUNE	CUT	N/A	TOT. INF.	PERCT. INF.	TOTAL	PERCENTILE
0.0- 2.9	186.154	3.692	4.308	0.000	8.000	4.120	194.154	92.794
3.0- 4.9	8.410	0.410	0.410	0.000	0.821	8.889	9.231	4.412
5.0- 6.9	5.026	0.513	0.308	0.000	0.821	14.035	5.846	2.794
TOTAL	199.59	4.62	5.03	0.00	9.64	4.61	209.23	100.00
PERCENT	95.39	2.21	2.40	0.00	4.61			

BASAL AREA PER ACRE FOR HOST TREES

HEALTHY	PRUNE	CUT	N/A	TOT. INF.	TOTAL
0.3925	0.0491	0.0463	0.0000	0.0954	0.4879

APPENDIX TABLE 4

STATISTICAL ANALYSIS FOR HOST TREES

South Rim, Grand Canyon

	Est. Ave. No. of Trees Per Acre[1/]	Standard Error	Coefficient of Variation
Healthy	199.59 ± 30.67	31.20	218.31
Prune	4.62 ± 1.33	1.36	411.11
Cut	5.03 ± 1.14	1.16	321.59
Tot. Inf.	9.64 ± 2.17	2.21	319.68
Total	209.23 ± 31.38	32.02	213.70

1/ 95 percent confidence limits.

SUGGESTIONS FOR A PROJECT WORK PLAN
FIRST FOLLOW-UP TREATMENT

Extension Area B
Grand Canyon Dwarf Mistletoe Project

1. Delineation of Extension Area B

Extension Area B is bounded on the south by a telephone line, and on the east by the road to Grandview Lookout Tower. It is bounded on the north by the Original Control Area, which included a 300-foot strip along both sides of the old alignment of East Rim Drive. The old alignment of East Rim Drive is still distinguishable, except where it coincides with the new alignment. Flagging the north boundary before scouting and treatment begins will help avoid overlap into the Original Control Area. The west boundary is near Duck-on-the-Rock.

If the follow-up treatment is likely to take more than one summer, scouting and treatment should begin in the portion of Extension Area B treated in 1966. This portion of Extension Area B, since it is the oldest treated portion, is likely to have the greatest number of seed-bearing dwarf mistletoe infections.

2. Scouting for Infected Trees

Scouting, if thoroughly done, should take about as much time as the actual treatment. Crew members should understand the importance of closely checking each tree. Binoculars will be needed for examination of large trees. Seedlings and saplings should be examined thoroughly. Scouting on overcast or cloudy days is extremely difficult and should be avoided if possible.

The area should be divided into scouting units. This can be done by extending stringlines from the south to north boundaries. The stringlines should be 1 to 2 chains apart. Scouting should be carried out in each stringed-off area before treatment. Trees with infections should be flagged for treatment.

Dwarf mistletoe often occurs in small centers or pockets. Pockets that were treated in 1966-1969 can be distinguished by evidence of past pruning, felling, or poisoning. Trees in the vicinity of previously treated pockets are the most likely to contain infections. They should be examined with particular care.

Branch swellings or dense clusters of branches may indicate a dwarf mistletoe infection. However, the only reliable way to confirm an infection is to locate dwarf mistletoe shoots. Old infections missed during the previous treatment should be easily visible. Recent infections will be more difficult to see. They will be located near the needles at the ends of branches.

3. Pruning and Cutting Guides

a. Cut - Trees in the 8-inch and larger diameter classes that are moderately or heavily infected (infection classes 3, 4, 5, and 6, 6-class mistletoe rating system). Bole infections in trees in the 8-inch and larger diameter classes are not important and should not be considered in rating.

b. Prune - Trees in the 8-inch and larger diameter classes that are lightly infected (infection classes 1 and 2). Since bole infections are not important in trees of this size, possible invasion of the bole by a branch infection is unimportant. All infected branches, including those with infections that may have invaded the bole, should be pruned.

c. Cut - Trees in the 6-inch and smaller diameter classes that are moderately or severely infected (infection classes 3, 4, 5, and 6). Also, cut trees in the 6-inch and smaller diameter classes that are lightly infected (infection classes 1 and 2), but contain bole infections or branch infections that have invaded the bole. The following table should be used to determine if a branch infection has invaded the bole:

Branch diameter at bole (Inches)	Minumum safe distance from bole to closest shoots (Inches)
Under 1	6
1 to 2	8
2 to 3	10
3 to 4	12

d. Prune - Trees in the 6-inch and smaller diameter classes that are lightly infected (infection classes 1 and 2) and do not contain bole infections, or branch infections that have invaded the bole.

e. Cut - Trees that were frilled and poisoned during the last treatment, but failed to die. Small numbers of these trees are scattered throughout the area. The largest concentration is at the west end of Extension Area B in the southeast quarter of Section 3.

If large portions of the crown are removed by pruning, isolated healthy branches should not be left since they are likely to contain latent infections. If there are enough live branches above the highest infected branch, pruning should extend above the highest infected branch by 2 to 3 whorls.

Branches should be pruned off flush with the trunk.

When trees are climbed for pruning, the climber should look for infections that are not visible from the ground. A ground observer should be working with the climber and directing him to infections visible from the ground.

4. Records

As during past treatments, a record should be kept of the number of trees actually pruned or cut. This can be done by the crew foreman. As work progresses, he should tally all pruned and cut trees by size class. Three size classes should be used: seedlings, trees up to 6 feet high; saplings, trees from 6 feet high to $4\frac{1}{2}$ inches d.b.h.; poles and larger, trees over $4\frac{1}{2}$ inches d.b.h.

5. Estimating Cost of Follow-up Treatment in Extension Area B

Cost and time records for the first follow-up treatment made in 1954 and 1955 in the Original Control Area may be helpful in estimating costs for the first follow-up treatment in Extension Area B. Cost and time records for the 1954 and 1955 treatments are as follows:

		1954	1955
a.	Total man-hours	2,600	5,540
b.	Total number of trees treated	3,033	8,136
c.	Man-hours per treated tree	0.85	0.68
d.	Cost per acre	$12.00	$10.00
e.	Cost per treated tree	2.14	1.41

Records on man-hours and cost (items a, c, d, and e) were for the total job--laying out stringlines, scouting, pruning or cutting, and travel to and from the job. Total number of trees treated (item b) included trees of all sizes, whether pruned or cut.

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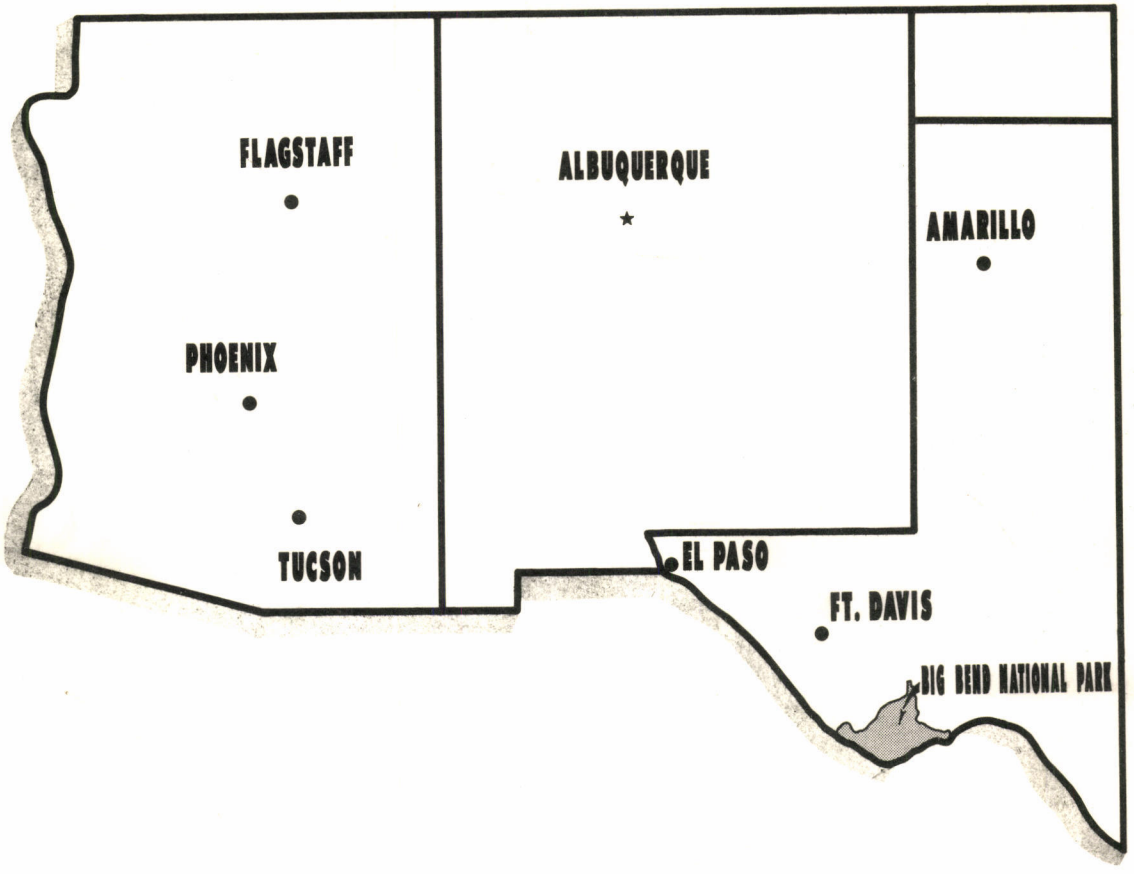

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Additional information concerning this report or other forest insect and disease problems can be obtained by contacting the Forest Insect and Disease Management Branch listed below.

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